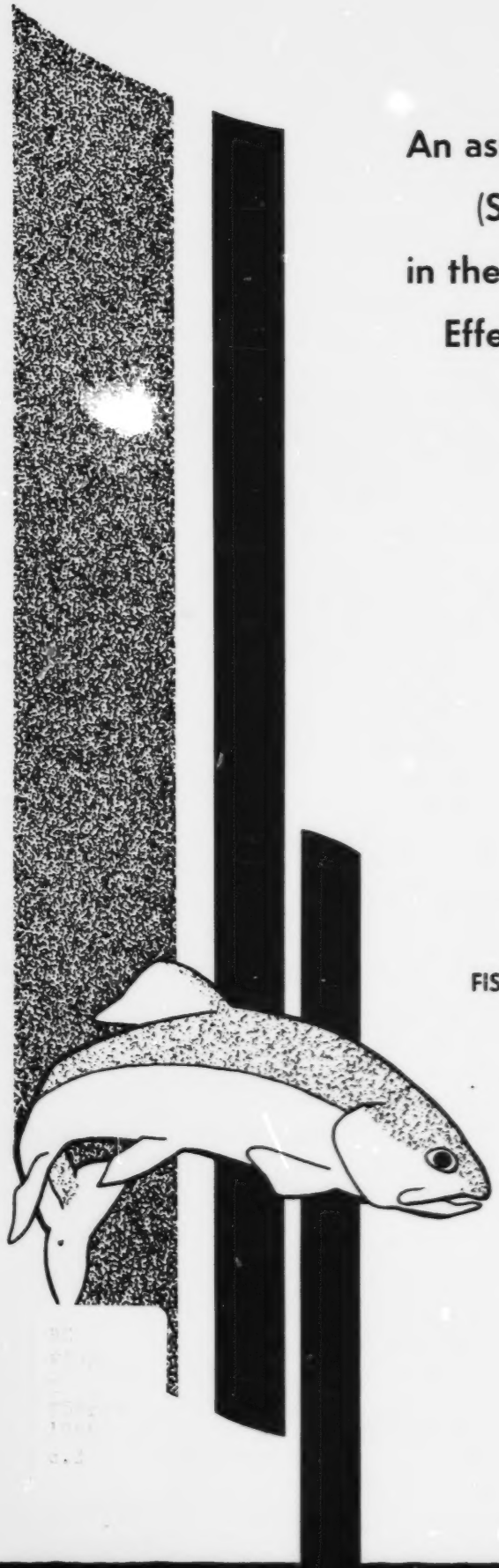

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by

P. A. Slaney

FISHERIES MANAGEMENT REPORT No. 89
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AN ASSESSMENT OF THE RAINBOW TROUT (Salmo gairdneri) POPULATION IN THE UPPER NECHAKO RIVER AND THE EFFECTS OF A SPORTFISHERY CLOSURE

by

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ABSTRACT

Slaney, P.A. An Assessment of the Rainbow Trout Population (Salmo gairdneri) in the Upper Nechako River and the Effects of a Sportfishery Closure. 1986. Fisheries Management Report No. 89. 37 p.

Rainbow trout inhabiting the Upper Nechako River were studied to document the population size, to determine the effectiveness of a sportfishery closure, and to evaluate the survival of stocked juvenile trout. Population enumeration and sampling was conducted at an upper "index reach" from 1983 (pre-closure) to 1986 (post-closure). Numbers and standing crop of catchable wild trout (> 20 cm) increased, two and 3.2 fold respectively. Corresponding increases in mean size of trout, age, and spawning frequency also occurred. Mean weight increased 64%, and 18% of the trout were > 0.5 kg by 1985 in contrast to 0% > 0.45 kg prior to the closure. Standing crop of wild trout in the index reach in 1986 approached earlier predictions of carrying capacity (Slaney et al. 1984 MS). At other study sites, examined less intensively, trout were less abundant although size and age structure were similar.

Survival of stocked juvenile trout (Premier Lake strain) was exceptionally low (1 - 2%) within the 10 km stocking site; fish apparently moved throughout the river. Preliminary results from stocking of stream strain (Blackwater River) in the "index reach" suggested higher survival, restricted movement, and comparable growth to wild trout in the river, although further assessment is required in 1987.

Fisheries management implications are that the population has recovered rapidly from over-exploitation; restoration should continue provided (1) appropriate special and restrictive regulations are invoked when the sport fishery is re-opened, (2) an adequate flow regime is maintained, as recommended by Slaney et al. (1984), and (3) restorative measures are initiated in tributaries to increase spawning and juvenile rearing areas. Further fish enhancement measures are also recommended to maximize sport fishery opportunities in this previously underrated recreational river.

ACKNOWLEDGEMENTS

This project could not have been completed without the energy, enthusiasm and cooperative efforts of Dennis Ableson, Regional Fisheries Biologist, Omenica Sub-Region. Several other fisheries biologists and technicians provided dedicated effort, well beyond what could be expected over the years, including Bill Harrower, Bob Land, Morley Rempel, Gary Alexander, Gerry Oliver and Brenda Dixon; this report represents the positive end result of their long hours on the Nechako River.

Additional cooperative effort and enthusiasm were provided by Alan Martin, Regional Biologist, East Kootenay Sub-Region, and Rick Morley, Manager, Fish Habitat Protection and Inventory Section. Assistance in the field was also contributed by Bob Little, Mike Whately and John Bell.

The manuscript was reviewed and edited by Dr. Thomas G. Northcote, Professor, University of British Columbia, which is greaty appreciated. Word processing was accomplished by Doris McKay and Bing Warner, and assistance with drafting was provided by Itsuo Yesaki.

The Department of Fisheries and Oceans, through Rod Bell-Irving and Gordon Ennis, provided data on physical parameters and added information on trout distribution in the river.

Finally, the support, interest, and historical knowledge provided by Hill and Marion Larson, who reside at Larson's Canyon on the Upper Nechako River, deserve special thanks.

INTRODUCTION

Stream fisheries in British Columbia account for 30% of angler days expended on freshwater sport fishing in British Columbia (Anon. 1985, Reid 1986) and greater than half of this effort is directed at resident salmonids on streams (Warner 1980 MS). Roderick Haig-Brown (1965) observed two decades ago that "streamfishing is in the highest possible demand, especially among the more knowledgeable anglers, and no amount of lake fishing, even of superior quality, can compensate for it". Preference studies elsewhere in western North America support this statement (Gordon et al. 1969). Of Idaho anglers, 66% preferred fishing for rainbow trout on streams, compared to 34% on lakes (Mallet 1980). The Nechako River, near Prince George in the central interior of British Columbia is typical of many large streams in British Columbia where a sport fishery has been active for rainbow trout, char and whitefish for several decades.

Earlier assessments of fish populations in the Nechako River suggested the rainbow trout (Salmo gairdneri) and char (Salvelinus confluentus) populations were insignificant (Envirocon 1985 MS) and angler effort and catch success were low (Envirocon 1983 MS). In 1983 rainbow trout were enumerated in the upper 5 km of the river and their abundance was found to be low, (ca. 25% of predicted carrying capacity, compared to the amount of prime habitat available (Slaney et al. 1984 MS). Simultaneously, several other streams in the province were surveyed and it was concluded that populations of trout were largely depressed, particularly in accessible reaches (Slaney et al. 1984 MS). Restrictive regulations and rotating closures (Martin and Bell 1984) were subsequently instituted at several streams in the province. At the Nechako River a sport fishery closure and experimental stocking of large yearlings were initiated in 1984 to rebuild the rainbow trout population to an estimated capacity calculated from a Habitat Quality Index (HQI; Binns 1982).

Little information was available on the effects of stream fishery closures aside from Martin (1983) and Martin and Bell (1984) for cutthroat trout in the East Kootenays, and no results were available on stocking of juvenile resident trout in streams in British Columbia (Howard Paish and Assoc. 1986). Population studies and sampling were, therefore, conducted during 1983 to 1986 to determine (1) the abundance of rainbow trout in the river, (2) the effects of the fishery closure, which was restricted to the Upper Nechako River (upstream of Vanderhoof, Fig. 1), and (3) the effectiveness of stocking two strains (lake and stream) of juvenile trout to augment the population.

STUDY AREA

The Upper Nechako River originates at Murray Lake, located 2.6 km upstream of Cheslatta Falls at 53° 38′ lat. and 124° 58′ long. In 1952 the river was impounded for hydroelectric power by construction of Kenney Dam, south of Cheslatta Falls (Fig. 1). Thirty-nine km of the mainstem river, that supported a large resident sport fish population, were eliminated by the reservoir. Nine km of the river were permanently dewatered downstream of Kenney and the flow diverted from the reservoir into the small Cheslatta River, then through Cheslatta and Murray lakes. The Nechako River has little inflow from tributaries until its confluence with the Nautley River, 90 km downstream from Cheslatta Falls.

The flow regime in the river is regulated, and releases of water are affected by several factors including snow pack and rainfall in the reservoir watershed, hydroelectric demands, flood control in the Fraser River, and flow requirements to protect salmon populations (Fisheries and Oceans 1984). Mean annual flow from recent records (1980 to 1986) from a gauging station near Cheslatta Falls is 61 m^3/sec compared to a historical, pre-impoundment flow of 197 m^3/sec. (G. Ennis, pers. comm. 1986; Dept of Fisheries and Oceans). However, the natural spring freshet has been shifted to mid-summer to provide a cooling discharge (280 to 290 m^3/sec) to protect a major sockeye salmon population that utilizes the river for migration within the river downstream of Nautley (Fig. 1).

Gradient and substrate of the Upper Nechako River are diverse. Steeper gradients, associated with a dominance of cobble, boulder and bedrock substrates, are evident in Reach 1, 3B and 5. Reach 2 and upper Reach 4 are intermediate in gradient, and they are dominated by gravel to cobble substrates. Reach 3A and lower Reach 4 are mainly slough-like at regulated spring flows (60 m^3/sec) and the substrate mainly consists of sand, fine gravels and, in one location, Fort Fraser to Nautley, silt and aquatic weeds.

The lower Nechako River, downstream of Reach 5 and Vanderhoof, is more similar to the lower gradient reaches in the upper Nechako, although there are two reaches of intermediate gradient (Reach 6 and 8) with some rapids. There is a sport fishery for resident salmonids in these latter areas, and at the confluence with tributaries, but this study concentrated on the Upper Nechako River.

Physical characteristics of the river vary by reach (Table 1) and they are described in detail in Slaney *et al.* (1984). The length of the Nechako River is 260 km from the outlet of Murray Lake, including 118 km to the end of Reach 5, or the Upper Nechako.

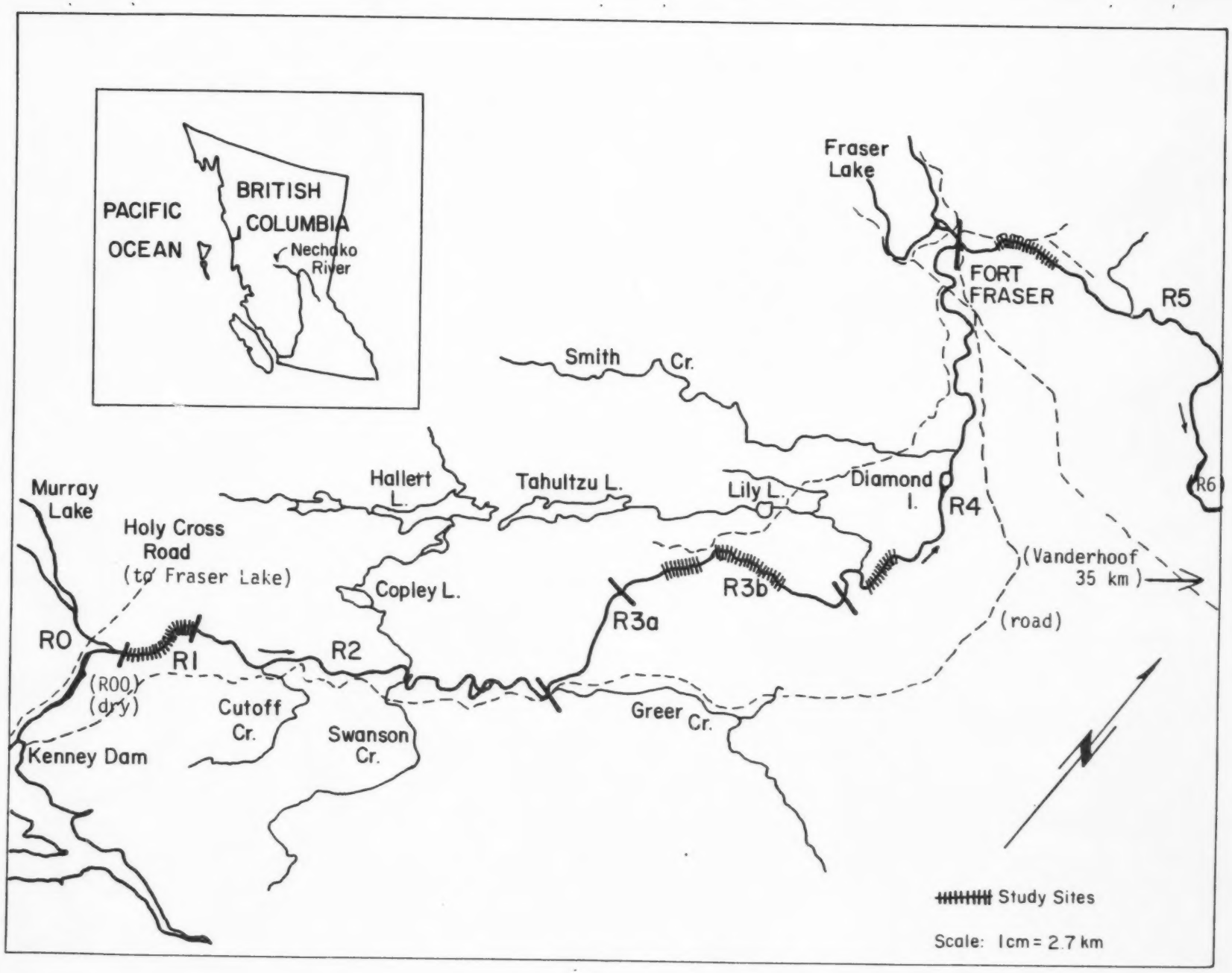

Fig. 1. Upper Nechako River and main tributaries.

Table 1. Physical habitat composition, length and mean width of Reaches 1 to 5 in the Upper Nechako River at a flow of 60 m^3/sec (from Slaney et al. 1984 M.S., Appendix 4) (excluding Reach 0; 2.6 km).

	Reach 1	R2	R3A	R3B	R4	R5
Pools (km)	44	19	25	12	9	22
Glides	31	28	14	45	60	47
Riffles	25	23	4	35	24	22
Flats	0	30	57	9	7	9
Mean width (m)	52	85	73	101	84	95
Length (km)	5.1	29.2	7.5	13.9	30.7	30[a]

[a]Slaney et al. 1984 MS included only 22 of 30 km

The annual mean water temperature in the Nechako River at Fort Fraser (1953 to 1960) and Vanderhoof (1955 to 1976) is 7.1 C and 6.9 C. Lower temperatures occur from November to April coinciding with ice cover (range near 0 to 4 C; monthly mean), and higher temperatures occur in May to October (range 8 to 18 C, monthly mean) (Envirocon 1981 MS).

Water chemistry analyses of samples collected from the Upper Nechako indicate a moderately oligotrophic river with a total dissolved solids (TDS) of 42 to 58 mg/l and relatively low concentrations of dissolved nutrients (NO_3N and total P) during early summer (Slaney et al. 1984 MS).

The river is inhabited or utilized for migration by six species of fish of recreational and commercial value including rainbow trout (Salmo gairdneri), bull trout (Salvelinus confluentus), chinook salmon (Oncorhynchus kisutch), sockeye salmon (O. nerka), mountain whitefish (Prosopium williamsoni) and white sturgeon (Acipenser transmontanus). Several other coarse fish species inhabit the Nechako, with suckers (Catostomus spp.) and northern squawfish (Ptychocheilus oregonensis) dominating total fish biomass throughout the river (Envirocon 1981 MS; Slaney et al. 1984).

The Upper Nechako to Cheslatta Falls is navigable throughout its length by boat, although jet motors are preferred at existing base flows. Access from the road system is also available at several points (Fig. 1). Additional recreation and boat launching sites are planned by the British Columbia Forest Service. The Nechako is rated as a Class A recreational river by a canoeing society (D.H.G. Ableson, pers comm.).

METHODS

PHYSICAL PARAMETERS

Flow records for 1983 to 1986 were obtained from the Department of Fisheries and Oceans. A flow gauging station was located ca. 8 km downstream of Cheslatta Falls. A continuous water level recorder was maintained through each year and daily flows were calculated from a stage-discharge relationship derived from metering.

Temperatures and total gas pressure (TGP) were continuously recorded in the Upper Nechako near Cheslatta Falls from spring to autumn in 1986 by the Department of Fisheries and Oceans. In 1985 to 1986 water temperature at substrate level was recorded continuously with a thermister attached to a data logger, and all records were corrected by frequent calibrations. TGP was measured with a Novatech tensionometer. Previous measurements of TGP in Reach 1 indicated supersaturation reached 110% which was primarily caused by entrainment of air at Cheslatta Falls. (This level can be sufficient to cause sublethal gas bubble trauma for fish in surface waters; Alderdice and Jensen 1985).

ENUMERATION OF RAINBOW TROUT

Rainbow trout were enumerated throughout Reach 1 (length 5.0 km excluding the plunge pool of Cheslatta Falls) during late June to early July each year from 1983 to 1986, and in early September in 1986. Conventional techniques of seining and electrofishing were not effective owing to the large size, turbulence of trout habitat, and low conductivity of the river. Trout were counted by underwater or "snorkel" observation within standardized counting lanes as described by Slaney and Martin (1987). The river was stratified into a shore zone (ie. 2 lane widths on each shore zone) and a larger mid-channel zone. Width of counting lanes was the mean of four to six replicated measurements of visual distance; i.e. the mean distance underwater that subadult to adult trout could be identified. All counts were separated into four size classes (10-20 cm, 20-30 cm, 30-40 cm and 40-50 cm, fork length) because it has been demonstrated that experienced underwater observers can estimate fish length within 2.5 cm of measured length (Griffith and Fuller 1979 MS). Counts per lane were expanded, within shore and mid-river strata, using the mean width of the reach.

Underwater counts were made by 4 to 6 experienced swimmers equipped with dry or wet suits and snorkel gear. Trout were counted to one side and directly in front of each swimmer within lanes in both shore and mid-channel zones. Adjacent swimmers compared observations at frequent intervals to minimize duplication of counts. Population estimates were not made when visibility was < 2.0 m because counts were negligible when visibility was 1.5 m in Reach 3B (1984) and Reach 5 (1986).

Additional observations of salmonid distribution during June to September in 1985 and 1986 were made by two swimmers positioned in a shore and mid-channel lane within 36 to 49 random sites in Reaches 1 to 5. These counts were made for an average duration of 20 to 25 min by staff of the federal Department of Fisheries and Oceans.

During early summer in 1985 a replicated Petersen mark-recapture estimate was conducted in Reach 1 (Martin and Slaney 1986 MS). Seventy-eight trout 20-30 cm in length and 97 trout 30-50 cm in length were tagged at the posterior base of the dorsal fin using dark red and light pink Floy tags. All fish were captured by angling with barbless baited (roe) hooks, anaesthetized with 2-phenoxyethanol, measured, weighed, scale sampled, and then released after recovery. Deeply hooked fish or "bleeders" were not tagged; rather, the line was cut and they were released. A hooking and handling mortality assessment was conducted for three days, utilizing 27 fish captured from the plunge pool at Cheslatta Falls, and each was subjected to the same procedure as described previously. Percentage mortality (11%) was substracted from the initial numbers tagged and released (Martin and Slaney 1986 MS). A mean Petersen estimate was, thereby, obtained from three replicated visual counts (n = 3) of tagged and untagged trout within Reach 1.

The mean Petersen estimate by size class was compared to the expanded underwater estimates, and a correction factor (x 2.9) was established for the latter because expanded counts in lanes produced estimates that consistently underestimate catchable trout populations (Martin and Slaney 1986 MS; three rivers in British Columbia). This factor was applied to the mean of all expanded underwater estimates conducted in Reaches 1 to 5.

Similar population estimation was planned for Reach 3B and Reach 5 from 1984 to 1986. However, as a result of visibility limitations, only a single count was obtained during late June in 1984 in 3 km sections of Reach 5 and Reach 4 (above Diamond Island) in 1986 (Fig. 1). Two replicated counts were also conducted in 1986 within Reach 3B; upper, 2 km; lower, 4 km.

Lengths of study sections were determined in the field, boundaries marked on 1:50,000 scale maps, and later measured from the maps. Widths were measured with a calibrated range finder (Ranger Model 620) permitting calculation of section areas in hectares.

SAMPLING OF RAINBOW TROUT

Owing to the size of the river, low conductivity and fast current within trout habitat, sampling attempted with seining, and particularly electrofishing, was of limited effectiveness in 1984 to 1985. For example, earlier intensive seining throughout the river resulted in the capture of only 46 rainbow trout (Envirocon 1981). Therefore, angling (bait, flies,

lures) was the principal method of capture to compare age and size composition of catchable wild trout before and after closure of the fishery. Angling was conducted in June to early July from 1983 to 1986 in Reach 1 and within Reach 3B and 4 in 1985 to 1986. Additional standardized angling was carried out by a consulting company (Western Renewable Resources; Lewynsky) at sites within Reach 1, 2, 3 and 4 during June, July, August and September of 1986 (Lewynsky 1986).

All trout were measured for fork length and a scale sample removed. A subsample (ca. 50) was weighed to the nearest 10 g utilizing a spring balance. Scales were mounted on coded gummed labels, then pressed into plastic from which photomicrographs were made on a 3M microfiche reader-printer. Aging was carried out by three readers, and agings that differed were re-interpreted. Incidence of spawning checks on the scales was also recorded for each sampling year.

JUVENILE STOCKING AND EVALUATION

A lake strain of rainbow (Premier Lake hatchery fish, partially of domestic origin) was stocked into the Upper Nechako River to increase the rate of population restoration under the fishery closure. In 1984 6400 lake strain (age 1+, clipped adipose; mean weight, 24.4 g) were dispersed from a boat in mid-September in 5 km of Reach 3B at 25 sites within runs, glides, rapids and at the sides of canyon pools. An additional 9,900 (age 1+, clipped adipose; mean size 128 mm and 25 g; 1 SD = 18 g) were dispersed on September 12, 1985 in the same section, but over a distance of 10 km. The prescribed stocking rate was calculated by assuming survival to catchable size (> 20 cm) would be 15%. Preliminary counts by snorkeling indicated a low abundance of wild trout. Thus, at an average weight of .25 kg the standing crop would be approx 50% of a predicted standing crop capacity (14.2 kg/ha) calculated from HQI (Binns 1982).

Stream strain of rainbow trout (progeny from wild adults collected from the Blackwater River, 90 km from Vanderhoof) were also stocked into the Upper Nechako system on June 26, 1986 within areas where electrofishing and underwater surveys indicated wild trout were under capacity. Three thousand two hundred and eight-five were stocked at six sites in the lower 5 km of Greer Creek, a tributary where density of juvenile wild trout was low. Mean size was 32.0 g (1 SD = 11.2), each clipped right maxillary. Two other groups, marked left maxillary, were stocked into the mainstem in Reach 1 and the upper 2 km of Reach 2. These fish were dispersed in groups of 100 to 500 at 10 stocking sites. One group of 2725 with a mean weight of 33.6 g (1 SD = 10.7) was nose-tagged (4.5% tag rejection) whereas the second group of 3172 weighing 25.9 g (1 SD = 7.7) was untagged, thus enabling a later comparison of relative survival at size of release. Of the total of 5897, 4936 were stocked

within Reach 1, excluding the plunge pool of Cheslatta Falls which was not stocked.

An assessment of survival of lake strain from the 1984 and 1985 stockings was conducted by enumerating numbers of adipose clipped and unclipped (wild) trout during underwater observations in Reach 3B in 1986. A preliminary estimate of the survival of stream strain from late June to early September of 1986 was also carried out by underwater observation. However, identification of maxillary clips proved difficult. Rather, the presence of an eroded dorsal fin, which is typical of hatchery-reared trout, was utilized; thus, a ratio of hatchery to probable wild trout was established. This was applied to the expanded population estimate which was multiplied by the established correction factor (2.9).

RESULTS

FLOW, TEMPERATURE AND TOTAL GAS PRESSURE

Flows have been regulated to accommodate several user demands including generation of power for an aluminum smelter and for sale into the provincial grid, flood control on the Fraser River system and for the protection of valuable salmon populations. Thereby, the natural spring freshet has been shifted to mid-summer for six weeks (Fig. 2). Mean annual peak flow ranged from 280 to 290 m^3/sec during 1983 to 1986. During the trout rearing period, flows were maintained at 57 to 68 m^3/sec from May to early July, sharply raised to 280 m^3/sec for six weeks, (with fluctuations) then rapidly reduced to approx 30 m^3/sec by September except in 1985 (60 m^3/sec; Fig. 2). During mid-autumn to early spring, flows were maintained at 30 to 32 m^3/sec. This regime has been greatly altered, and reduced in the 1980's by 70% from the natural pre-impoundment flows prior to 1953, when 9 km of the Nechako River canyon were permanently dewatered by diverting regulated flows through the Cheslatta drainage (Fig. 1).

Average daily water temperatures in 1985 and 1986 were less than 5C from November to April, and near 0 to 2C from mid November to mid March (Fig. 3). Mean temperatures in the trout rearing period (May to October) and annually were 12.7C and 7.4C respectively in 1985. In both years average daily temperatures reached an extended peak of 16 to 17C during July to early September (Fig. 3). At another station (Reach 4) the extended peak was ca. 2C higher (data on file).

Total gas pressure, (TGP) which was monitored intensively by the Department of Fisheries and Oceans near Cheslatta Falls, was on average 6% to 13% above saturation during spring to summer, as a function of flow (r^2 = .82, $p < .05$; Fig.

4). However, the increased turbulence of higher flows shifted the slope of this relationship downwards with distance downstream (G. Ennis, pers. comm. 1987). Excess TGP presents moderate and high levels of risk of "gas bubble trauma" to salmonids in the range 109 to 112% and > 112% respectively at near surface depths (J. O. T. Jensen, pers. comm. 1987).

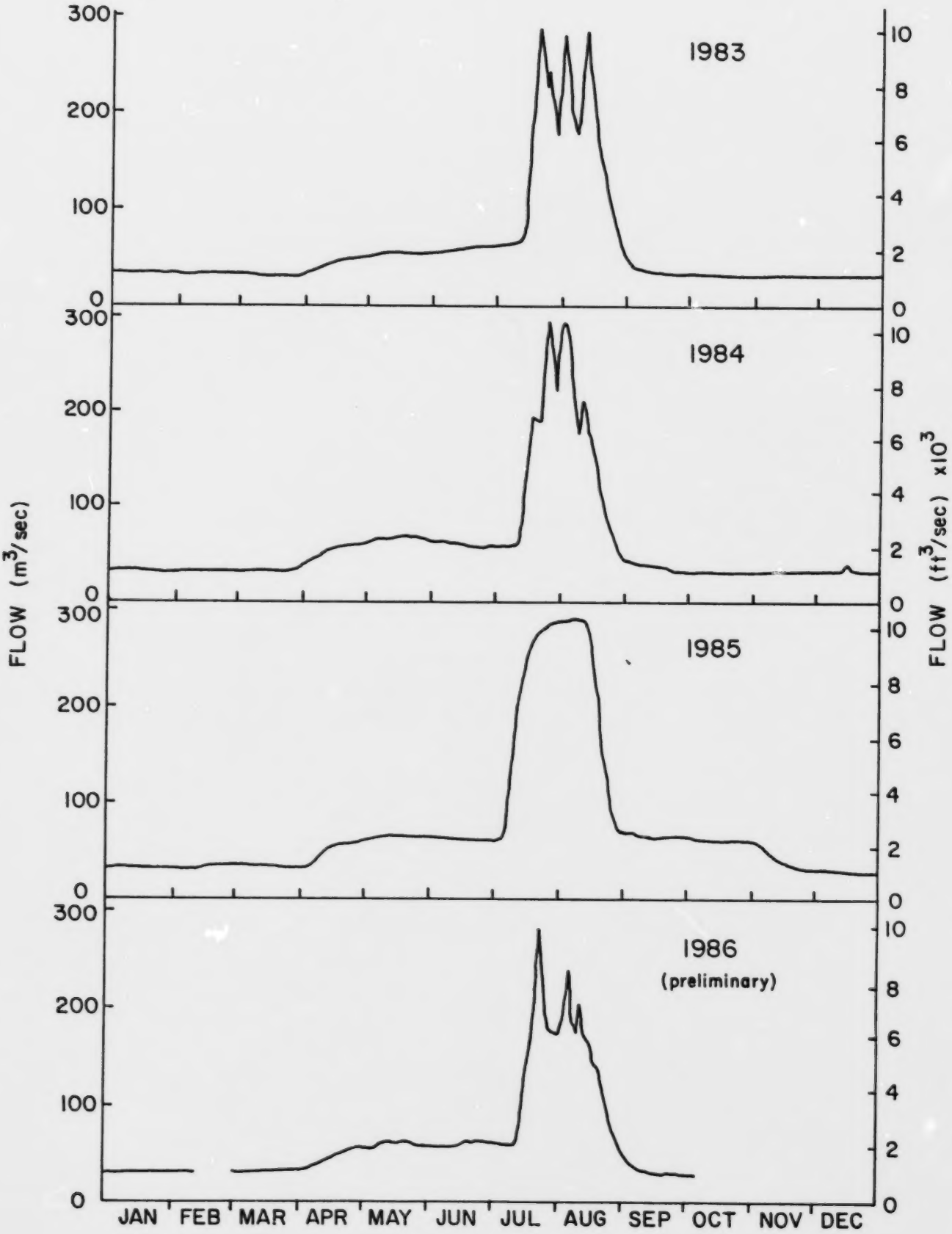

Fig. 2. Annual flow regime in the Upper Nechako River from 1983 to 1986.

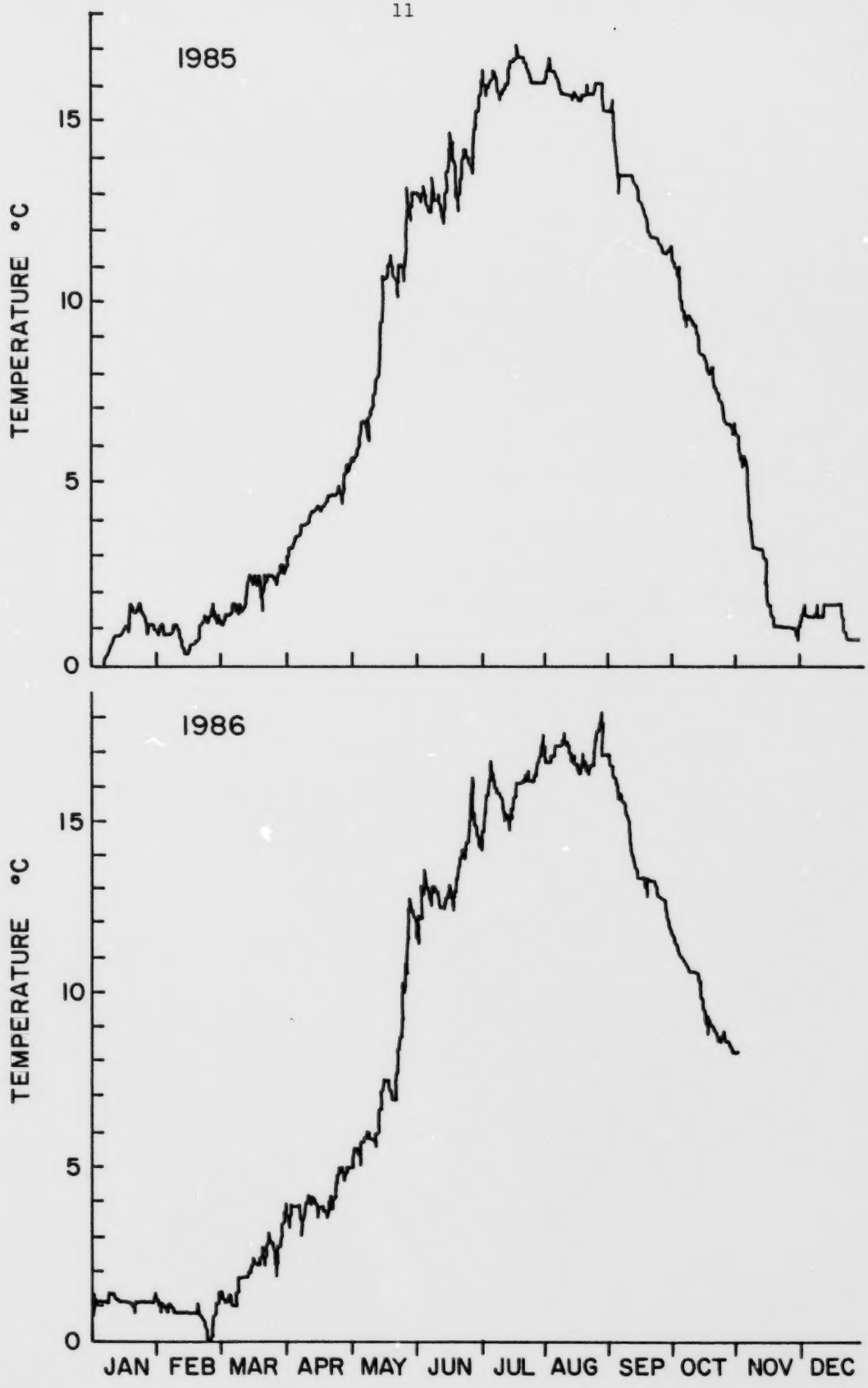

Fig. 3. Average daily water temperature (C) approximately 7 km downstream from Cheslatta Falls during 1985 and 1986 (data from Department of Fisheries and Oceans).

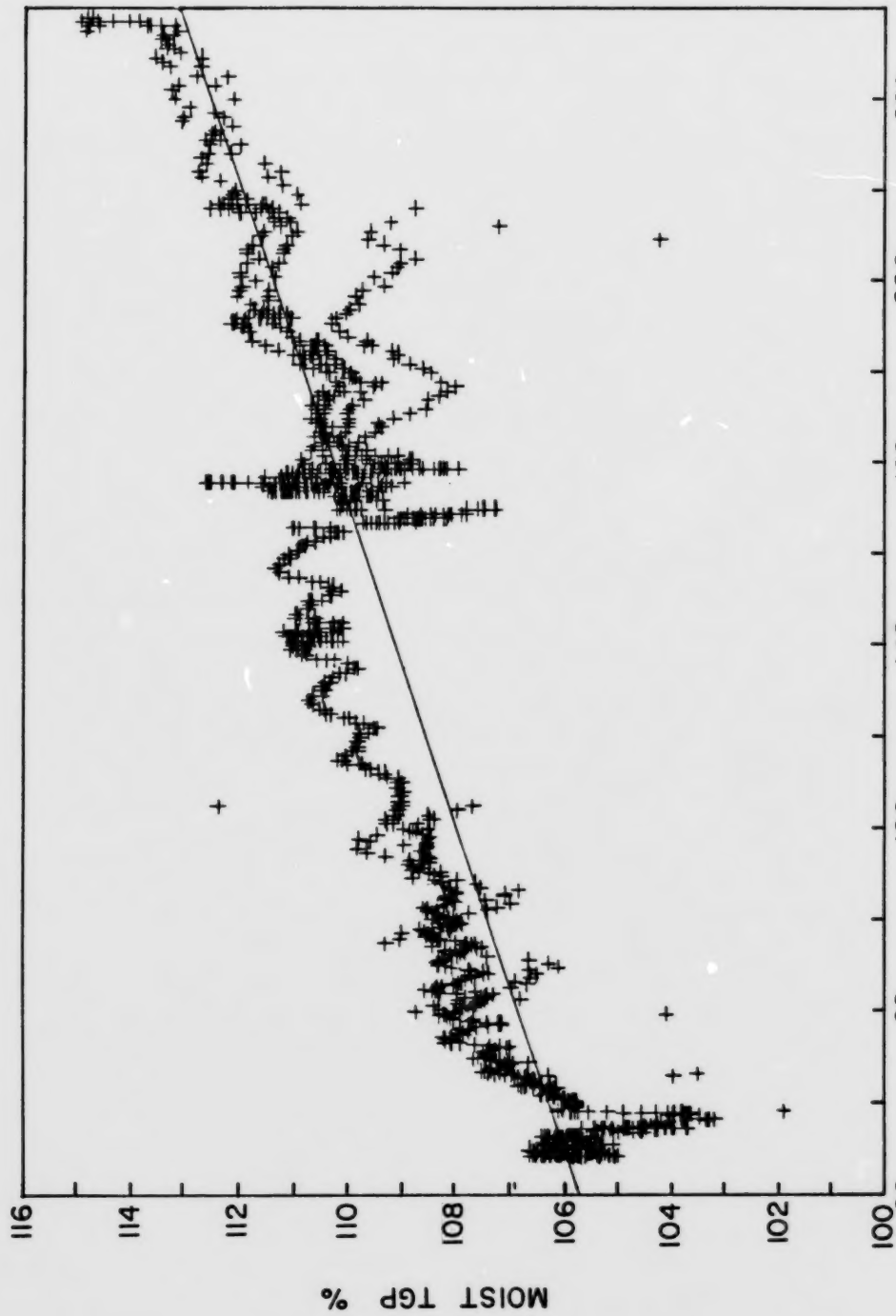

Fig. 4. Total gas pressure at Cheslatta Falls during spring to summer of 1986, and its relationship to flow, Q (r^2 = .82; TGP = 0.029Q + 105.14) (from Department of Fisheries and Oceans 1986).

THE RAINBOW TROUT POPULATION IN REACH 1 AND EFFECTS OF THE FISHERY CLOSURE

Prior to the fishery closure, which was instituted in April 1984, the population estimate of catchable (> 20 cm) wild rainbow trout in Reach 1 was 427. Three years after the closure > 20 cm trout increased on average to 850 or a 100% increase (Fig. 5; slope significant at $p < .05$). There was a corresponding increase in > 30 cm trout, although the > 30 cm size class was not separated in 1983. Trout 10 - 20 cm increased in abundance, but varied greatly, particularly in 1986 (Table 2). Most of these fish were estimated to range from 15 to 20 cm in length. Trout < 10 cm were sparse, or only ca. 1% of the total estimated population of trout in Reach 1.

Table 2. Population estimates by underwater censusof juvenile (< 10 cm), subcatchable (10 - 20 cm) and total rainbow trout in Reach 1 of the Upper Nechako River in 1983 to 1986.

	Year				
Size Class	1983	1984	1985	1986[1]	1986[2]
< 10 cm	-	0	6	10	0
10 - 20 cm	148	348	505	117	468
All Trout	575	916	1182	837	1424

[1] late June
[2] early September

Although the percentage of trout < 20 cm averaged 31% of the total enumerated by swimmers, they were rarely collected in angled samples. In 1986, numbers of trout 40 to 50 cm in length were also recorded by swimmers. Three percent and 8% of the catchable (< 20 cm) trout were estimated to be > 40 cm in length in June and September respectively. In the angled sample collected in June 1985 and 1986, 4% and 3% were in this size range. The largest rainbow trout sampled and observed in Reach 1 in 1985 was 46 cm and 70 cm, respectively. The latter, observed in lower Reach 1 by three snorkelers, and subsequently lost during angling, was typical in morphology to an anadromous trout. Aside from the < 20 cm size class, the size composition derived from the angled sample and the underwater counts were within 10 to 14% (Table 3).

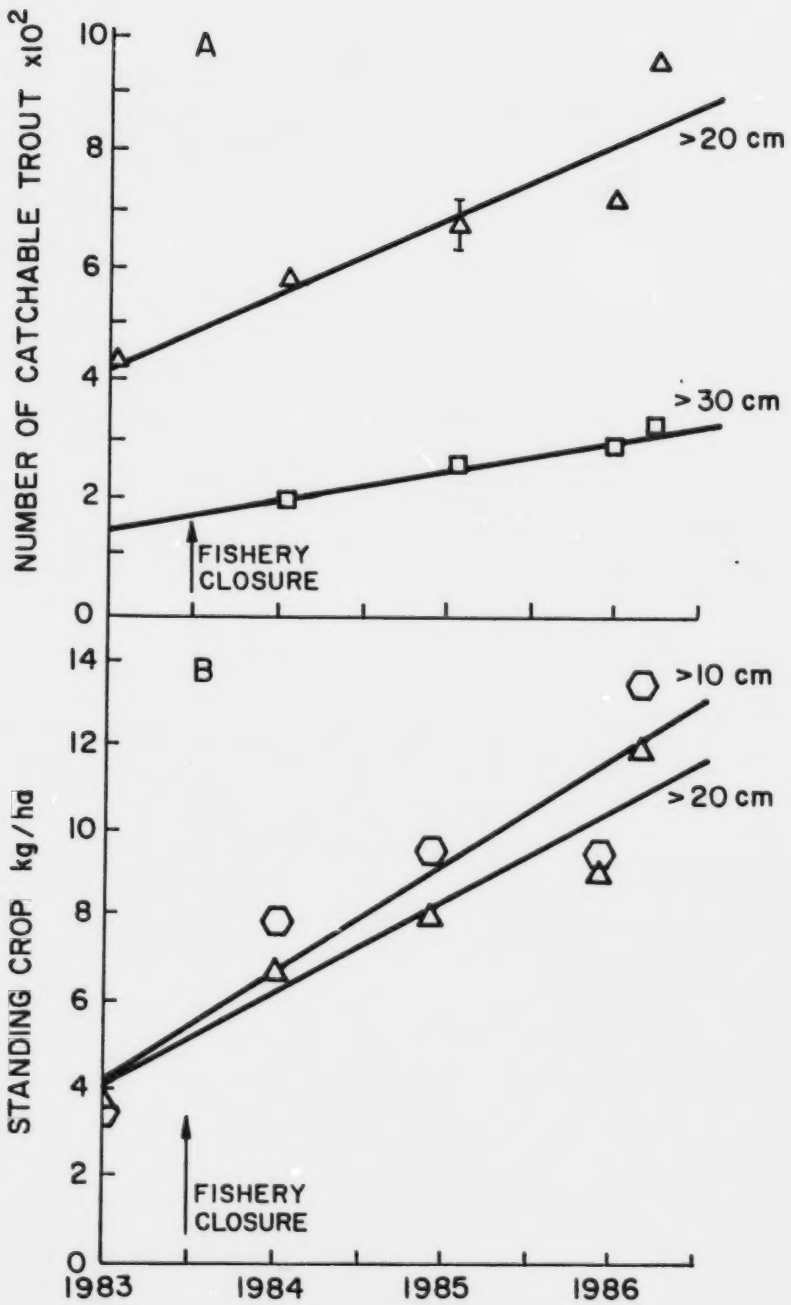

Fig. 5. Trends in population estimates (A) and standing crops (B) of two size classes of rainbow trout in Reach 1 of the Upper Nechako River from early July 1983 to Sept 1986. The sport fishery was closed after 1983 (vertical lines are ± 1SE, derived from replicated Petersen mark-recapture estimates; slopes significant at $p < .05$).

Table 3. Comparison of percent composition of catchable rainbow trout in three size classes based on two techniques in 1985 and 1986.

Year		20-30 cm June	20-30 cm Sept	30-40 cm June	30-40 cm Sept	40-50 cm June	40-50 cm Sept
1985	Count Estimate	63	-	37[a]	-	-	-
	Angled Sample	49	-	47[b]	-	4[c]	-
1986	Count Estimate	59	66	38[b]	26	3	8
	Angled Sample	46	-	51[b]	-	3[c]	-

[a] includes trout 40 - 50 cm

[b] 30.1 - 40 cm

[c] 40.1 - 50 cm

Corresponding increases in abundance per km and hectare were evident, whereby numbers of catchable trout peaked in 1986 at 142 to 191/km and 28 to 38/ha, a two-fold increase over 85/km and 17/ha in 1983 (Table 4). Standing crops increased substantially from 3.8 kg/ha in 1983 to 12.0 kg/ha in 1986 or >3.2 fold increase on average after 2.5 years of closure of the sport fishery (Table 5; Fig. 5). By 1986 total standing crop was approaching the level of biomass capacity predicted by HQI (14.2 kg/ha; Slaney, et al. 1984; from Binns 1982).

The marked increase in standing crop compared to numbers/ha was a result of a change in mean size. Mean weight and length of rainbow trout increased 64% and 20%, respectively, from 1983 to 1986 (Fig. 6, $p < .05$). Shift in the length frequencies were evident as early as July 1984 after two months of closure of the sport fishery (Fig. 7). For example, in 1983, only 12% of sampled population were > 32 cm, compared to 21% in 1984, 38% in 1985 and 33% in 1986. A high proportion (18%) of the trout were > 0.5 kg (1.1 lb) by 1985 when a large sample (191) was collected during five days of angling (Fig. 7), whereas, in contrast, no fish > .45 kg were sampled in 1983 (Fig. 6). The mean condition factor of the 1985 sample was 1.11 and the length-weight regression equation was ln wt = 2.82 ln len - 10.39 (Appendix 1).

The marked shift in size after the fishery closure can be explained by a corresponding shift in the age structure of the population (Table 6).

Table 4. Estimated densities of wild rainbow trout per km and per ha by size class within Reach 1 of the Upper Nechako River from 1983 to 1986.

	10-20 cm	20-30 cm	>30 cm	Total >10 cm	Catchable Total >20 cm
1983 July					
no/km	30	-	-	115	85
no/ha	6			23	17
1984 July					
no/km	70	75	39	183	114
no/ha	14	15	8	37	23
1985 June					
no/km	102	84	50	235	133
no/ha	20	17	10	47	27
1986 June					
no/km	23	84	58	165	142
no/ha	5	17	11	33	28
1986 Sept					
no/km	94	126	65	285	191
no/ha[a]	19	25	13	57	38

[a]based on the mean width at June flow; 57-60 m^3/sec

Table 5. Estimated standing crop (kg/ha) of wild rainbow trout by size class in Reach 1 of the Upper Nechako River from 1983 to 1986.

	10-20 cm	20-30 cm	>30 cm	Total >10 cm	Catchable Total >20 cm
July 1983	0.4			3.4	3.8
July 1984[a]	1.0	3.3	3.5	7.8	6.8
June 1985	1.5	3.7	4.4	9.6	8.1
June 1986	0.4	4.2	4.9	9.5	9.1
Sept 1986[b]	1.4	6.2	5.8	13.4	12.0

[a]mean weights from 1985 were utilized to calculate standing crop in 1984

[b]based on June area of river

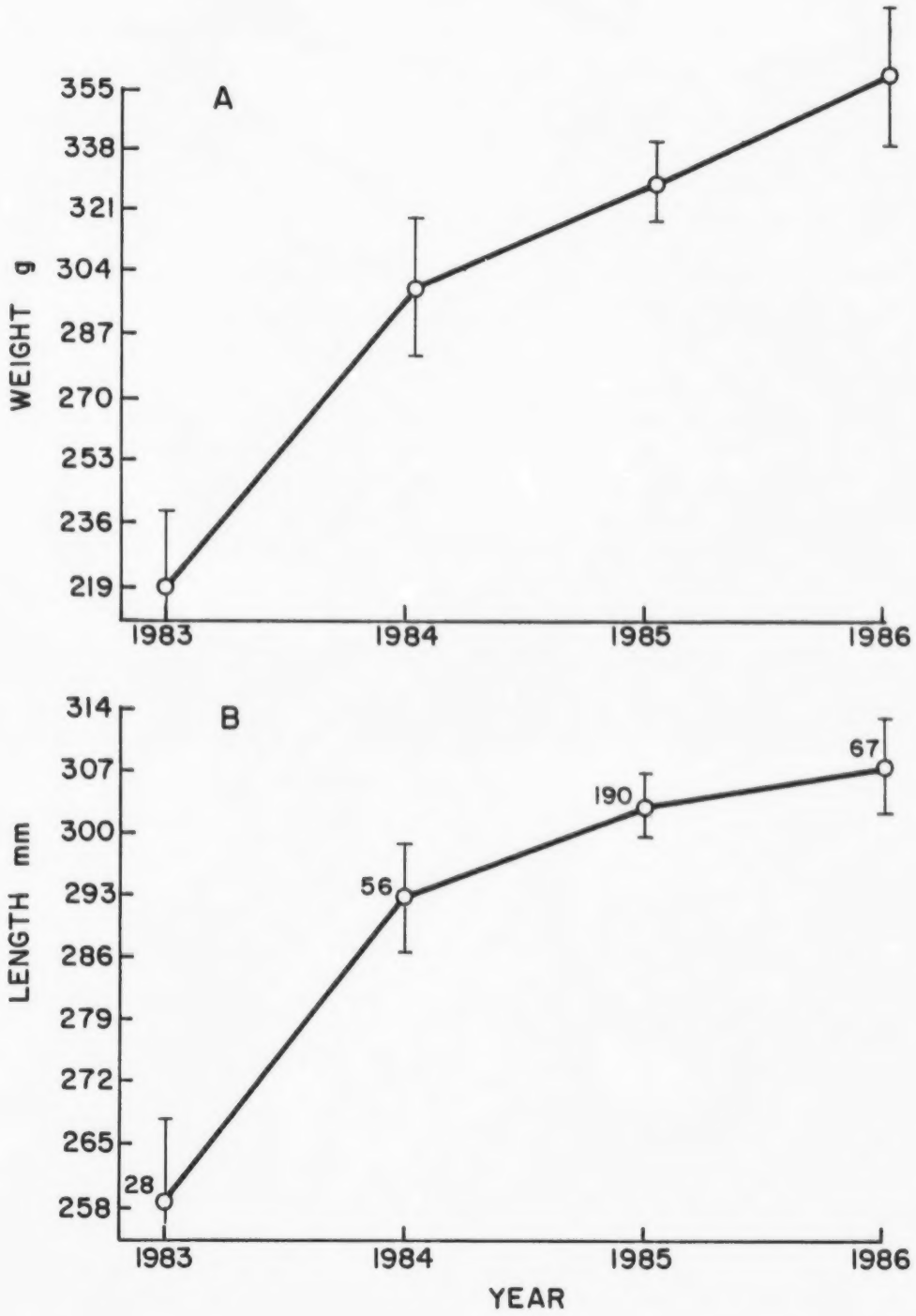

Fig. 6. Mean weights (A) and lengths (B) of wild rainbow trout angled during early summer in Reach 1 of the Upper Nechako River. The sport fishery was closed from 1984 to 1986 (vertical lines are $\pm$ 1SE; n = 28 - 190).

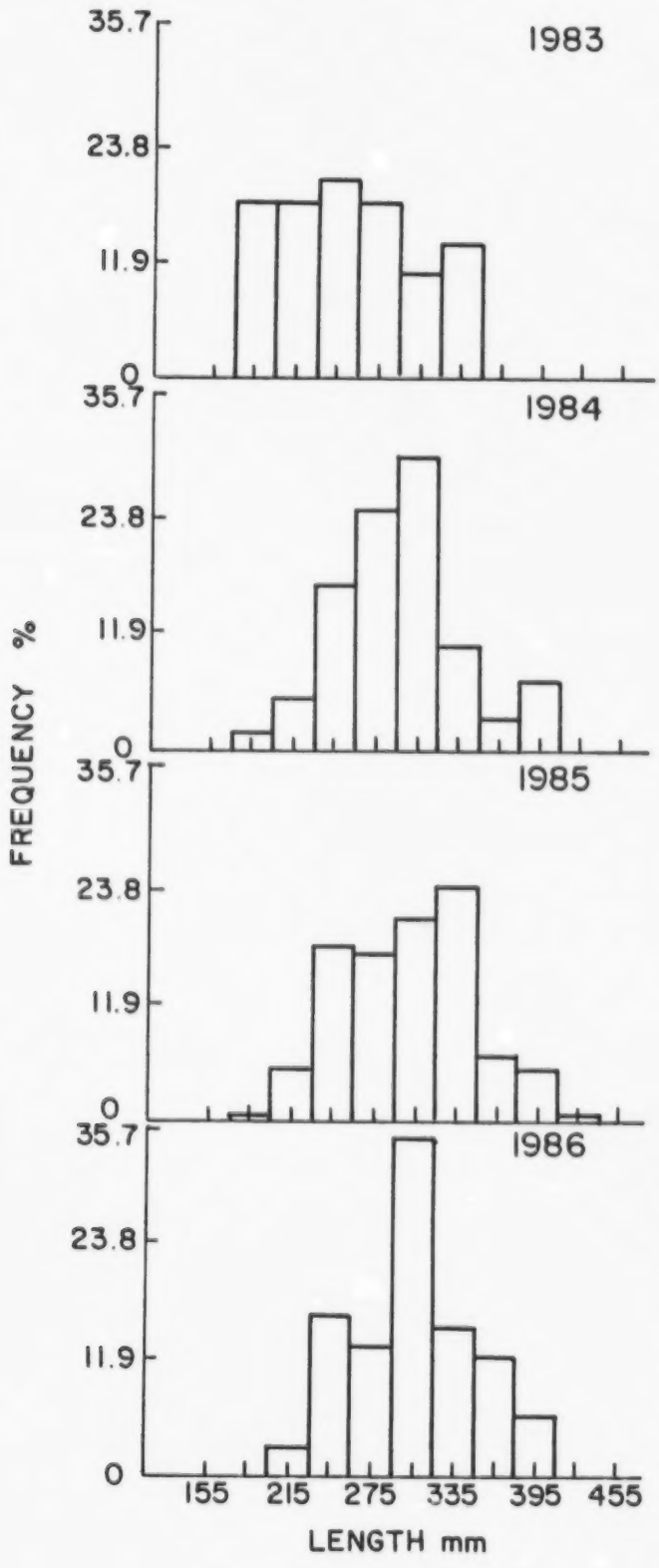

Fig. 7. Length frequency of rainbow trout in Reach 1 of the Upper Nechako River during mid June to early July in 1983 to 1986.

Table 6. Age composition of rainbow trout, sampled by angling techniques from mid-June to early July, 1983 to 1986 in Reach 1.

Year	n	Age 2+	Age 3+	Age 4+	Age 5+	Age 6+
1983	26	15%	65%	15%	4%	0
1984	51	12	49	35	4	0
1985	62	16	31	40	11	2
1986	67	17	47	24	12	0

Length at age of angled samples did not show consistent differences between years; the variance was high and sample size too small to detect differences. There was a trend towards increasing size at age with time since the fishery closure; age 2+ and 3+ were significantly greater in mean length after (1986) than before closure (1983) (Table 7).

Table 7. Length (± 95% CL) at age of rainbow trout in Reach 1 of the Upper Nechako River in early summer from 1983 to 1986.

	Age 2+	Age 3+	Age 4+	Age 5+
1983	199	257	315	310[a]
	(37)	(23)	(105)	
1984	229	277	314	362[a]
	(23)	(11)	(38)	
1985	225	272	338	370[b]
	(33)	(22)	(10)	(27)
1986	259	303	330	354
	(15)	(14)	(22)	(31)

[a] n = 1-2 samples
[b] includes 1 age 6+ fish (400 mm)

Scales from two years, 1983 and 1986, were interpreted for probable years of early rearing in tributaries. Assumed tributary rearing was detected by a slow growth period followed by rapid growth in the mainstem. Two years of tributary rearing dominated both years (Table 8). This variable duration of rearing in tributaries contributed to the high variation in length at age. Aging of scale samples from Swanson Creek, a productive tributary in Reach 2, supported these interpretations (data on file).

Table 8. Percentage composition of number of years of assumed rearing in tributaries (based on interpretation of scales sampled from wild trout in Reach 1 in early summer of 1983 and 1986).

	Years			
	0	1	2	3
1983	5	36	50	9
1986	8	47	42	3

The frequency of spawners (kelts and repeat spawners) increased sharply after the fishery closure, from 8% in 1983 to 32% in 1986 (Table 9). Spawners were dominated by age 4+ and 5+ fish, for example, 86% in 1986.

Table 9. Spawner frequency for trout collected by angling in Reach 1 of the Upper Nechako River in mid June to early July.

	1983	1984	1985	1986
% Spawners	8	14	27	32

ABUNDANCE, SIZE AND AGE OF RAINBOW TROUT IN REACH 3, 4 AND 5

The effect of the fishery closure was not examined within Reach 3 to 5 because water clarity restricted visual counts on most sampling trips. Fifty three wild trout were tagged in Reach 3B in 1985, but visibility was only 1.3 m, precluding a population estimate. In 1986 numbers of wild catchable trout (> 20 cm) per km and ha were 98 and 14.9 respectively in Reach 3B, and 205 and 26 respectively in Reach 4 (Table 9). Numbers per km in Reach 3B were approx 50% less than in Reach 1, whereas those in Reach 4 were similar to the latter. However, numbers per ha were lower, comparatively, because the river was approx 20 to 30 m wider.

Total standing crop was 6.0 and 9.8 kg/ha in Reach 3B

and Reach 4 respectively, which was on average 42 to 68% of that predicted with HQI (Slaney et al. 1984, from Binns 1982). Estimated numbers in Reach 5 were similar to Reach 4 although fish > 30 cm were lower (Table 10). However, total standing crops were similar to Reach 3B.

Table 10. Estimated numbers of wild rainbow per km and ha by size class in Reach 3B and Reach 4 (upper) in the Upper Nechako River in June 1986.

	10-20 cm	20-30 cm	> 30 cm	Total > 10 cm	Catchable Total > 20 cm
Reach 3B[a]					
no/km	32	47	50	130	98
no/ha	4.9	7.5	7.4	19.8	14.9
kg/ha	0.4	1.7	4.0	6.0	5.7
Reach 4[b]					
no/km	54	118	87	259	205
no/ha	7	15	11	32	26
kg/ha	0.5	3.4	5.9	9.8	9.3

[a] mean of two replicates of two sections, weighted by area
[b] observed single observation

Table 11. Estimated[a] population numbers per km and ha of rainbow trout in 3 km of Reach 5 of the Upper Nechako in July 1984[b].

	10-20 cm	20-30 cm	> 30 cm	Total > 10 cm	Catchable Total > 20 cm
no/km	144	107	37	288	144
no/ha	16.9	12.6	4.4	34	29.5
kg/ha[c]	1.3	3.0	2.1	6.4	5.1

[a] single count without replication
[b] calculations based on mean weights from Reach 3B sampled in 1985
[c] an additional 24 bull trout per km were also estimated, or 1 kg/ha > 10 cm

Mean length, weight and age structure of trout in Reach 3B in 1985 was similar to Reach 1 (Table 12). Samples in 1986 included trout from Reach 4, which had a higher frequency of smaller fish, but there was not a significant difference between years regardless ($p > .05$). Age composition in the samples was also similar to Reach 1, with older fish (age 4+ and 5+) comprising 38% of samples on average (Table 12). Forty two and 36% of the trout were > 32 cm in 1985 and 1986 respectively, slightly more than in Reach 1 (Fig. 8). Eighteen percent of the fish were > .47 kg and 4% were > .75 kg in Reach 3B (Fig. 8). The largest rainbow trout captured during 1985 and 1986 was 44 cm (.8 kg) and 40 cm respectively. Mean condition factor in 1985 was 1.04 compared to 1.11 in Reach 1, and the length-weight regression was ln Wt = 2.926 ln Len - 10.97. Spawning frequency in 1986 was 30%, and very slow growth was evident in the first 1 to 2 years, again similar to Reach 1.

Table 12. Mean length, weight and age composition (%) collected by angling techniques in June 1985 (Reach 3B) and 1986 (Reach 3B and 4).

	Mean Length (mm)	Mean Weight	Composition % Age 2+	Age 3+	Age 4+	Age 5+ (g)
1985 (±1SE)	306 (7.4) (n=53)	351 (23) (n=53)	19	38	31	12
1986 (±1SE)	282 (10.6) (n=31)	297 (30) (n=21)	23	43	20	13

TAG RECOVERIES AND MIGRATION

Few 1985 tags were recovered by sampling in 1986. Three tags were recaptured in Reach 1 where 138 trout or 21% of the population > 20 cm were tagged in June 1985. In Reach 3B only one recapture of a tagged fish was made during 1986. During snorkel observations in Reach 1 and Reach 3B in 1986, 6% and 3% of fish > 20 cm that were counted had tags, respectively. In comparison 16% were observed, on average, with tags in Reach 1 in 1985. Also no tagged fish were recaptured during intensive angling in the Cheslatta plunge pool in 1985 and in 1986. However, one tagged trout (30 cm) from Reach 1 was reported captured in the Nautley River during September, 90 km downstream from Cheslatta Falls. Tagged fish grew on average 58 mm and 166 g or an annual average gain of 63% in weight (Table 13).

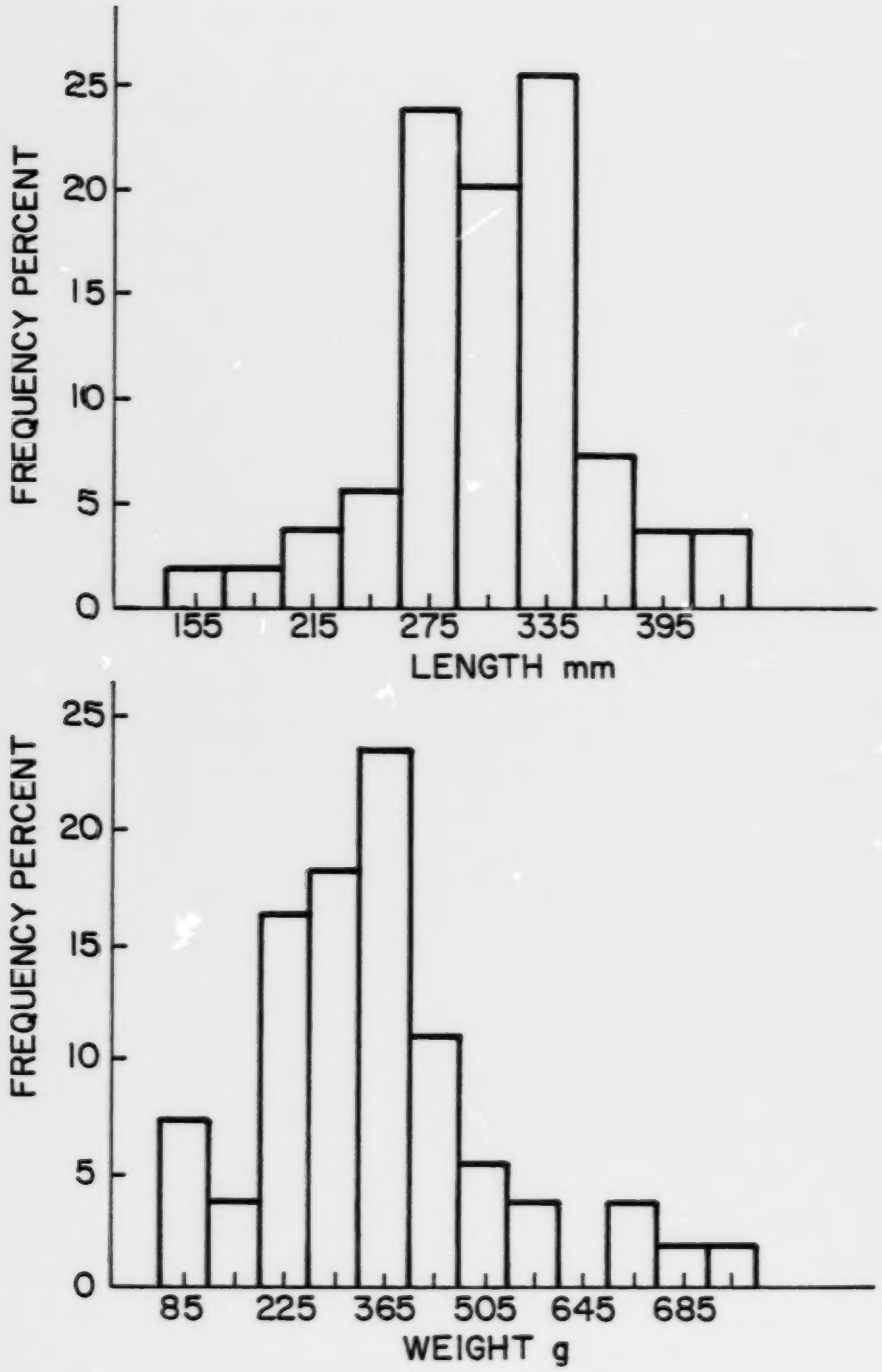

Fig. 8. Length and weight frequency of rainbow trout in Reach 3B during late June, 1985.

Table 13. Mean growth of tagged rainbow trout in the Upper Nechako River from June 1985 to June 1986 (n = 4).

	Length (mm) 1985	1986	Growth (mm) 1 year	Weight (g) 1985	1986[a]	Change (g) 1 year
Mean	279	337	58	265	431	166
(± 1 SD)	(19)	(9)	(26)	(62)	(48)	(104)

[a] 3 of 4 weight samples were calculated from regressions (Appendix 1) and these were the least change in size.

ESTIMATED SURVIVAL OF HATCHERY FISH

Lake strain juvenile rainbow, stocked into Reach 3B in 1984 and 1985, were enumerated by snorkel techniques in 1986. Estimated density and standing crop were very low within the stocking area. Approx 100 trout > 10 cm were estimated, based on adipose clip observations, or a survival rate in the stocking area of only 0.6% (Table 13). In Reach 1 ca. 20% of rainbow trout (stream strain) could not be discriminated as hatchery versus wild. If this is applied to Reach 3B, then maximum survival was 2.2%. In total, lake strain accounted for 7% of all rainbow trout observed in Reach 3B, yet their standing crop was negligible and none were captured by angling in 1985 or 1986 in Reach 3B (Table 14). However, two were captured by angling in other reaches. In 1985 one 240 g fish (283 mm) was captured 8 months later within Reach 1, after migrating 40 km upstream. A second fish was reported captured near Vanderhoof, ca. 90 km downstream. Also, two of these fish were observed in Reach 1 by swimmers during 1985 and 1986. Accordingly, the lake strain of hatchery fish apparently migrated throughout the river, and survival was very low within the stocking area.

A preliminary population estimate of the stream strain (Blackwater River) was conducted 2.5 months after stocking. Excluding the Cheslatta plunge pool, survival was 10.4% based on underwater counts, although a large proportion of the wild trout (10-20 cm) may have been stream strain. An average of 20% of the observed trout could not be classified, which would increase the estimate to 12.5%. Blackwater stream strain was distributed in both 10 - 20 cm (71%) and 20 - 30 cm (29%) size classes and thereby accounted for an estimated 3 kg/ha of additional standing crop in Reach 1 (Table 14). In total they accounted for 36% of the fish observed in Reach 1 in September 1986. Two were captured by angling in Reach 1 during September; 20 and 24 cm in length with left maxillary clips. There was no recorded movement into other non-stocking areas (Reach 3-5) of the river even though this strain had been stocked prior to the peak flow period.

Table 14. Estimated density and standing crop of hatchery rainbow trout Premier Lake strain in Reach 3B during June 1986.

	10-20 cm	20-30 cm	Total > 10 cm
no./km	5.2	4.1	9.3
no./ha	0.7	0.6	1.3
kg/ha[a]	0.05	0.14	0.19

[a]mean weight of wild trout in corresponding size classes was utilized to calculate standing crop.

Table 15. Estimated density and standing crop of hatchery rainbow trout (Blackwater River - stream strain) in Reach 1 during September, 1986.

	10-20 cm	20-30 cm	Total > 10 cm
no./km	73	30	103
no./ha	17	7	24
kg/ha	1.3	1.7	3.0

Underwater observations were also conducted in the lower 2 km of Greer Creek in September 1986. Only 3 hatchery fish (right maxillary clip) were located. However, ca. 300 were observed in Reach 3A, 5 km from Greer Creek 2 weeks after stocking (data on file). Two were captured by angling in Reach 4 21 km downstream during late July, one month after stocking Greer Creek. Three additional trout from this group were captured in September by seining in Reach 2, including two sites 10 and 20 km upstream from Greer Creek. The mean length of a sample of six maxillary clipped fish in Reach 2 was 213 mm (1SD=12) or 115 g compared to a group mean of 30 g, 3 months previously. In comparison, stocking of the tributary apparently induced more movement of the stream strain than mainstem stocking in Reach 1.

DISCUSSION

ABUNDANCE OF RAINBOW TROUT

Extensive enumeration of rainbow trout in the Upper Nechako demonstrated this central interior river was inhabited by a substantial rainbow trout population by 1986. Systematic underwater enumerations, previously developed and evaluated by Martin and Slaney (1986 MS) and Slaney and Martin (1987 MS) were utilized to obtain population estimates at four reaches in the river, with emphasis on Reach 1 where population estimates were made from 1983 to 1986. The accuracy of underwater census was tested at Reach 1 in 1985 with replicated Petersen mark-recapture estimates, thus providing a correction factor to apply to the mean of expanded underwater counts (Martin and Slaney 1986 MS). This factor was applied to all estimates, aside from Reach 1 in 1985 when the mark-recapture method was utilized directly. Martin and Slaney (1986) found that the mark detection rate was less for smaller fish than larger fish in the Upper Nechako River. In contrast to smaller rivers, the average incidence of detection of 20-30 cm tagged trout in Reach 1 was 10% compared to 19% for 30-40 cm trout. This implies that estimates for smaller fish, particularly < 20 cm, were significantly underestimated in the Nechako.

The same correction factor was also applied to other reaches and to Reach 1 at 50% lower flow in September. Populations in Reach 3B, 4 and particularly Reach 5, were probably underestimated because they are at least 50% wider and mainly as deep as Reach 1. The September estimate possibly overestimated the population because Martin and Slaney (1987) found the correction factor increased with flow in the same section of the St. Mary River. However, inspection of Fig. 5 suggests the overestimate was not large in Reach 1 of the Nechako.

Sample reaches were not randomly selected on the river, but rather represented reaches that would be more highly utilized in the sport fishery. Lewynsky (1986) sampled more widely in the Upper Nechako and catch of rainbow trout per hour was consistently highest in Reaches 1, 3B and 4 (.83 to 5.67/hr) but moderate to high catch rates were also evident in Reach 2 (.50 to 2.17/hr). No sampling or enumeration was carried out in Reach 3A (7 km) or the lower 5 km of Reach 4 (Fort Fraser to Nautley). These areas appeared marginal in habitat suitability for trout, similar to the Lower Nechako, where suitable trout habitat is available mainly within sections of Reach 6 and 8 with higher velocities. Based on additional underwater observations by two swimmers (one shore, one mid-channel) at 49 random sites for an average duration of 20 to 25 min, 51% were highly utilized by rainbow trout (range:no./site, wild, 1-30; hatchery 1-300) in Reaches 1, 2, 3A, 3B, 4, 5, and 6 (Department of Fisheries and Oceans, data on file). Also, two days of seining from a boat

throughout Reach 2 at the end of September, 1986 produced a total catch of 34 rainbow trout > 20 cm at seven of twelve seine sites (including 6 hatchery fish of stream strain) (L. Jaremovic pers. comm.). Accordingly, adult rainbow trout are abundant and widely distributed throughout the Upper Nechako River.

These results contrast with the earlier results and interpretations of Envirocon (1981 and 1985). Extensive and intensive sampling of fish populations with fine mesh seines was conducted throughout the Nechako River, yet only 46 rainbow trout were captured (Envirocon 1981). Also, few juvenile trout were captured in tributaries. These results subsequently led to inferences that the trout population was too sparse to require rearing flows adequate to maximize usable habitat for adult trout (Envirocon 1985). In summary, the population of rainbow trout in the Upper Nechako is substantially larger than these early surveys suggested (Envirocon 1981), and in one reach rainbow trout have expanded by 1986 to a standing crop similar to predictions from HQI (Binns 1982).

EFFECTS OF THE FISHERY CLOSURE

The abundance of catchable trout in Reach 1 of the Upper Nechako responded rapidly to a fishery closure, doubling in numbers and increasing > 3-fold in total standing crop from 1983 to 1986. Mean size in the catch increased rapidly from 219 g to 316 g as larger and older fish were retained in the population. Similar effects on age and size structure were recorded by Martin (1983) and Martin and Bell (1983) at the Wigwam and Upper St. Mary rivers, respectively, after a fishery closure. Also, at the St. Joe River in Idaho closure of main tributaries to angling resulted in a much greater abundance of both small and large cutthroat trout, compared to a control stream (Johnson and Bjornn 1975).

The sample size of the angled samples from 1983 to 1986 could be a potential source of error in evaluation of the fishery closure. However, this is discounted because angled samples have consistently matched underwater observations in the St. Mary River (Slaney and Martin 1987 MS, Martin and Slaney 1986 MS). In the Nechako, aside from trout < 20 cm, results were comparable. Also, independent sampling reported by Lewynsky (1986) in Reach 1 resulted in a similar mean size and standard deviation despite the smaller sample size, $n = 36$, $\bar{x} = 312$, $1SD = 52$; versus, $n = 67$, $\bar{x} = 307$, $1SD = 47$).

The closure of the Upper Nechako also gradually increased the percentage of spawning fish but a corresponding increase in juveniles has fluctuated. By 1986 spawners in Reach 1 comprised 32% of the catchable population and averaged 34.8 cm ($1SD = 3.3$) in length. Most of these fish were "mended kelts" indicating they spawned about a month earlier. The higher incidence of spawners, however, should have resulted in a greater abundance of 10-20 cm fish (i.e. age 1+ and 2+) in the river by

1985 and 1986 as more recruits entered the river. There was a marked increase in 10-20 cm trout in Reach 1 in 1985, but a sharp decline was evident by June 1986. This was associated with an extreme drought in the tributaries during July and August of 1985; for example, the lower reach of Swanson Creek was dewatered in midsummer. This was followed by extremely low temperatures and severe ice conditions in both the tributaries and the mainstem during November. This suggests it will require more than three years for the trout population to attain an equilibrium.

Underwater observations by swimmers during early summer suggest there was still prime trout habitat unused within all reaches (including Reach 1 which was stocked in 1986 with Blackwater stream strain to more fully utilize this habitat). The high growth rates in the mainstem also support the interpretation that rainbow trout in the Upper Nechako have not yet reached an equilibrium.

Surveys of tributaries including Greer and Swanson creeks indicate they are utilized for spawning and initial rearing, typical of trout populations that inhabit large streams co-inhabited by coarse fish (Scott and Crossman 1973). Analysis of scales from Nechako rainbow support this life history interpretation because only a small percentage of adult fish showed mainstem growth at age 0+, and few fish < 15 cm were observed by swimmers. In another large stream, the Snake River in Wyoming, many juveniles were found to migrate from tributaries primarily as large yearlings, approx 20 cm in length (Kiefly 1978). Unfortunately, tributary rearing area is currently limited in availability and in quality in the Upper Nechako. For example, Greer Creek is affected by sedimentation and some of the other productive streams are impassable as a result of beaver dams (Tredger 1984 MS).

STOCKING EVALUATIONS

Stocking of juvenile trout that were lake strain from Premier Lake was not effective in augmenting the abundance in rainbow trout in Reach 3B of the Upper Nechako River. It was estimated that after two years this strain comprised only 7% of rainbow trout in this reach, and estimated survival was negligible ranging from a minimum of 0.6 to a maximum of 2.2%. Because none of these fish were recaptured in 1985 and 1986 in Reach 3 and 4, this low range in survival seems probable. However, four fish were captured or observed 40 to 90 km upstream and downstream of Reach 3B. This indicates that movement from the stocking site did occur. Similar examples of upstream and downstream movement from the stocking area, although generally of less distance (< 25 km), are reported by Cresswell (1981). Lake strain may have a greater propensity to migrate (Northcote 1969), although fingerling and subcatchable rainbow trout of lake origin have been successfully utilized for river stocking in Wyoming

(R.W. Wiley pers. comm.; Wiley and Dufek 1980). Size at stocking affects survival or return to the creel (R.W. Wiley pers. comm.; Howard Paish and Associates 1986), and this may have also reduced survival in the Upper Nechako. Although the mean weight of the lake strain was 25 g, only 20% were > 35 g whereas 37% were < 15 g, i.e., highly biased to small fish.

The performance of stream strain cannot be evaluated, until 1987. A preliminary assessment in Reach 1 during September, 1986 suggests that survival through the summer was > 10%, and if small fish were 50% less detectable than large fish (Martin and Slaney 1987 MS), then 20% survival was possible during the first summer. In contrast to the lake strain, only 9% were < 15 g and 12% > 35 g as a result of a more intensive grading practice in a different hatchery. Preliminary results on growth and movement after one summer suggest the stream strain was more adapted to riverine conditions. Further population estimation, utilizing Petersen mark-recapture techniques, should be conducted in Reach 1 and 2 in 1987 to document growth, movement, and survival in relation to backcalculated size and size group from tags.

FISHERIES MANAGEMENT IMPLICATIONS

Results of this study on the rainbow trout population of the Upper Nechako River have important implications including (1) fisheries regulations for continued restoration of the population, (2) regulation of the flow regime in the river, and (3) sportfish enhancement. There is a need to integrate these aspects to realize sportfishing opportunities at the Upper Nechako. Prior to the fishery closure, surveys in the mainstem and tributaries suggested a depressed stock of rainbow trout and a corresponding low effort fishery (Envirocon 1981, 1983; Slaney et al. 1984). The closure has rapidly resulted in restoration of the population in Reach 1, including a high proportion of large trout > 30 cm in length in the catchable population. It is now sufficient to support a "quality fishery" (Lewynsky 1986) in a stream that has been rated as a Class A recreational river. However, there is a serious risk that re-opening the fishery with liberal regulations could rapidly eliminate these gains in numbers and size of trout (e.g., Martin and Bell 1983)

Fisheries Regulation and Restoration

At the St. Mary River near Cranbrook, 22% of the cutthroat were removed in a 3.3 km section (14 ha) with only 7 hr of effort per ha (Slaney and Martin 1987). In Reach 1 of the Upper Nechako 28% of trout > 20 cm were removed by < 5 days of angling effort by three anglers. This potential "harvest" was highly biased to fish > 30 cm whereby 36% were removed from 5 km or 26 ha in the Nechako (Slaney and Martin 1987 MS, Martin and Slaney 1986 MS). McPhee (1966) also reported that only 32 hr of

angling were required to remove 50% of the trout population of a small Idaho stream. Similarly, in Colorado several years of research on small and large trout streams demonstrated that resident rainbow trout are easily overexploited (Anderson and Nehring 1984).

In overexploited populations of stream-dwelling trout, the catch is typically comprised mainly of young small fish, with a few remnant fish of moderate size (Anderson and Nehring 1984). Both decreasing average size and declining angling success rates are considered important indicators that a stock of fish is being overfished (Rounsefell and Everhart 1953). Prior to the fishery closure, rainbow trout of the Upper Nechako, using Reach 1 as an indicator, was clearly at the stage described by Nehring (1983). Catch success by the angling public was low (0.15/hr; Envirocon 1983) and tributaries were very sparsely populated with juvenile rainbow trout (Envirocon 1981).

In recognition of the high susceptibility of serious overexploitation, fisheries managers in the midwestern United States have shifted rapidly from liberal regulations to stream specific special regulations involving catch and release, bait bans and limited kill (i.e. size limits and low quotas). Nehring (1983) and Anderson and Nehring (1984), for example, have reported up to an order of magnitude increase in trout numbers, and substantial increases in mean size in the creel as a result of invoking catch and release regulations on overfished rivers in Colorado. This shift in management strategy has only started in some regions in British Columbia; many accessible resident trout fisheries have been depressed or depleted for a sufficient duration that their current status tended to be considered "natural" (Slaney et al. 1984).

Re-opening of the Upper Nechako to sport fishery will also require restrictive special regulations to ensure restoration of the fishery continues and a quality fishery is maintained. The Nechako River rainbow is an unproductive stock in the Ricker (1954, 1958) sense. The sustainable harvestable surplus is low because of several environmental stresses and limitations. Supersaturation of dissolved gas (TGP) is at sublethal levels because of diversion of the river over Cheslatta Falls (Fig. 4; Alderdice and Jensen 1985). Secondly, the Nechako River is subjected to an unnatural freshet that increases suspended solids during mid-summer, particularly in Reach 3 and 4 (eg. Lewynsky 1986). It is uncertain what the effects are, but re-analysis of depth and velocity data in Reach 1 and 3B suggests significant reduction in weighted usable habitat during the middle of the summer rearing period (G. Alexander pers. comm.). Also, the river is moderately oligotrophic with a TDS of 50 to 60 mg/l, compared to the Snake River in Wyoming where TDS is 180 mg/l (Kiefly 1978). In the latter, equivalent length at age of cutthroat trout is one year earlier, regardless of a slightly lower mean temperatures (6.8 C). Finally, tributaries that are utilized for spawning and yearling rearing (similar to the Snake

River) are impacted by sedimentation (Greer Creek) or beaver dams (Tahultzu and Smith creeks), or periodic drought conditions (Cutoff and Swanson creeks) (Tredger et al. 1985 MS). Tredger's (1984 MS) preliminary reconnaissance report stated that "low recruitment in areas of good habitat suggests a major problem with spawning population size". In contrast these streams are highly utilized by juvenile chinook which apparently migrate into them (Envirocon 1981). Accordingly, this indicates that the rainbow trout population in the Upper Nechako is sensitive to exploitation and regulations must reflect this sensitivity.

Regulation of the fishery should emphasize catch and release of wild rainbow trout and bull trout (which are sparse) under a bait ban (Burns 1984, Lewynsky 1986) throughout the Upper Nechako. However, to maximize recreational use, a restricted kill should be eventually permitted by setting a minimum size limit that protects a higher proportion of spawners. The mean size and dominant age of spawners was 35 cm and 4+, respectively, adding ca. 3 cm from age 3+ to 4+. A 35 cm size limit would protect a high proportion of the spawning population and, at the same time, permit a limited harvest of trophy size fish ranging from 35 to 50 cm, comprising approx 15% of the population. However, without a strong Regional commitment to both education of anglers and enforcement, poor compliance with the bait ban (necessary to reduce hooking mortality to < 5%) and the size limit could eliminate restoration (Lewynsky and Bjornn 1982 MS, Nehring 1983). For example, information notices should be installed at all access points throughout the river, a standard practice at the Madison and Big Hole rivers in Montana. In Colorado, "spot" television advertisements have been successfully utilized to attain compliance (Nehring 1983).

Restoration of the trout population throughout the Upper Nechako should continue, but habitat restoration measures should be undertaken, with support from the Habitat Conservation Fund. A program of beaver dam removal (blasting and trapping during spring) in the lower 5 km of tributaries would greatly increase spawning and rearing area to accommodate expanding spawner utilization. Similarly, restoring the complexity of rearing habitat in the tributary at the Cheslatta "gravel fan" in the old canyon would improve recruitment of yearlings into the mainstem. Several juvenile rainbow (0+ and 1+) were electrofished from this tributary in 1983 (data on file). Similarly, spawning gravels should be renovated and added to the pond headed tributary above the road bridge at Greer Creek, and at other similar sites at this main tributary that carries a significant sediment load during the spawning period.

Implications of the Flow Regime

The results of this study also have implications to regulation of flows in the Nechako River. Standing crop capacity was predicted from HQI (Binns 1982) at 14.2 kg, which was the only "state of the art" method available to derive an estimate

(Slaney et al. 1984 MS). The standing crop of wild trout in Reach 1 has expanded 3.2-fold and is approaching that estimate (excluding hatchery fish). Standing crops in other reaches are estimated at 42 to 63% of this predicted capacity. The increasing trend in Reach 1 suggests that other reaches have responded more slowly. However, complexity of habitat is generally less in these reaches and the rearing capacity may be reached at a lower level. Slaney et al. (1984) recommended a "sub-optimum flow regime" that would provide > 95% of usable habitat. Because the trout population in the Upper Nechako is recovering rapidly, a flow regime similar to the "sub-optimum" should be maintained (Slaney et al. 1984). A high level of risk resulting from lower flow regimes, proposed by Envirocon (1985), was emphasized by Slaney et al. (1984) and Mundie and Bell-Irving (1986) owing to unpredictable factors including (1) impacts of anchor ice, (2) predation and competition with coarse fish, (3) hydrologic sampling errors, and finally (4) the inherent risks associated with unproved "state of the art" methodologies for determining flow requirements for the protection of salmonids (Annear and Conder 1983, 1984; Slaney et al. 1984)

Based on a recent evaluation of sportfishing in the Upper Nechako (Lewynsky 1986), it was concluded that sportfishing opportunities declined at extreme flows and accessibility was near optimum at 85 m^3/sec. Mean sizes in the catch also declined from 24-32 cm to 20-26 cm in four reaches at a flow approaching 200 m^3/sec (7000 cfs). However, this must be integrated with the need for a short term flushing flow and the needs of other salmonids utilizing the river (Fisheries and Oceans 1984).

Fisheries Enhancement in the Upper Nechako River

Finally, there are implications relating to sport fisheries in enhancement in the Upper Nechako. Stocking of lake strain has not been effective and should be abandoned. Rather, stocking of stream strain initially appears more promising in terms of growth and survival, although no firm conclusions can be drawn until the evaluation is completed in 1987. In the Snake River, ca. 50% of juveniles migrate into the mainstem at age 1 and 1+ at a mean size of 21 cm (Kiefly 1978). This suggests a larger size at stocking may be necessary and a size-survival relationship may be comparable to that established for wild steelhead trout (Ward et al. 1986 MS). Intermittent stocking may prove necessary to attain carrying capacity in some sections of the river because of limitation in tributaries.

Other enhancement measures that should be eventually implemented include a scaled down design of a single rearing channel from the "washout zone" through "the gravel fan", utilizing water drawn upstream of Cheslatta Falls near Murray Lake (Goos 1986). Experimental improvement of adult rearing habitat in selected sections of the mainstem should also be attempted employing a debris collection design recommended by Harder (1983) at the Morice River. For example, underwater

observations have suggested a preference by rainbow trout for debris accumulations within moderate velocities and depths in the Nechako.

In summary, the sportfish population and sportfishery opportunities in the Upper Nechako River should not be underrated. The population has responded rapidly to a fishery closure based on research conducted since 1983 within an upstream reach. In 1986 both catch success and fishing conditions in Reach 1 and 3B equalled or surpassed stream fishing for trout in the "premier" Stellako River, and catch rates were comparable to renown trout rivers in northern Idaho (Lewynsky 1986). Measures to maintain fishing quality and continue restoration of the trout population of the Upper Nechako should be highly supported in the Fisheries Program of the Ministry of Environment and Parks.

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